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CONVAIR DIVISION OF GENERAL DYNAMICS CORPORATION

EVALUATION OF JOINT STRENGTH AND FATIGUE PROPERTIES OF AM-355 AND TYPE 321 CRES STAINLESS STEEL SPLICE PLATES

7E 2139

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EVALUATION OF JOINT STRENGTH AND FATIGUE PROPERTIES OF AM-355 AND TYPE 321 CRES STAINLESS STEEL SPLICE PLATES

OBJECT:

To determine the ambient temperature static joint strength and fatigue properties of four combinations of two types of splice plates with two hardnesses of Type 301 stainless steel sheet skin materials.

The following joint combinations were evaluated:

Joint Designation	Splice Plate	Stainless Steel Skin Material
A	AM-355	Type 301 (1/2 H)*
B	Type 321 CRES	Type 301 (1/2 H)
C	AM-355	Type 301 (EFH)!
D	Type 321 CRES	Type 301 (EFH)

CONCLUSIONS:

1. The combination of AM-355 splice plate with Type 301 (1/2 H) CRES sheet had approximately 10% higher tensile strength than the Type 321 CRES splice plate combination. Joint A tensile strength was 149,000 PSI vs. 136,000 PSI for Joint B.

2. The combination of either AM-355 or Type 321 CRES splice plates with Type 301 (EFH) stainless steel sheet yielded the same results; i.e., approximately 195,000 PSI.

3. In fatigue testing, the AM-355 splice joints started to leak slightly earlier than the Type 321 CRES when welded to both hardnesses of Type 301 stainless steel sheets. However, the AM-355 had a longer fatigue life than the Type 321 CRES before final failure occurred.

* 1/2 H = Half Hard
! EFH = Extra Full Hard

TEST SPECIMENS:

Standard 9-inch tensile coupons were machined of all the joint materials, both splice plates and skin materials.

The joint specimens were the standard pin-loaded, 38 inch long tensile specimens. Joints A and B were made in accordance with Figure 3. Joints C and D were fabricated in accordance with Figure 4. All joint specimens were production welded at Convair-Astronautics.

PROCEDURE:

All static testing was done on the 200,000 pound Tinius Olsen Universal Testing Machine.

The 9-inch tensile coupons were tested to determine the elongation and the yield and ultimate strengths of the joint materials. The materials were tested in both the longitudinal and transverse grain directions.

The ultimate static strength of joints A, B, C, and D was determined.

The rate of loading of all static testing was 0.001 inch per inch per minute (strain) up to the yield strength and 0.2 inch per minute (cross-head travel) to failure.

The fatigue testing was done with hydraulic rams, cycling the specimens approximately 6 times per minute. Prior to cycling, dye penetrant was applied to the welded joints. The welded joints were visually inspected during load cycling to determine the number of cycles at which the penetrant leaked through a crack in the weld. Load cycling was then continued until failure. Joints A and B were cycled between 0 and 2,190 lb/inch of width of specimen (A = 61,400 PSI, B = 62,400 PSI). Joints C and D were cycled between 0 and 1860 lb/inch of width of specimen (C = 53,600 PSI, D = 54,600 PSI).

RESULTS:

Joint Materials

The results of the static tests of the joint materials are shown in Figure 5. An attempt was made to obtain a yield strength 110,000 PSI. However, as a result of heat treatment, we received a yield strength varying from 60 to 90,000 PSI. We do not know what effect this would have on the final properties of the joint strength.

STATIC TEST OF JOINT SPECIMENS

The results of the static testing of joint specimens are shown in Figures 1, 6 and 7. Uniformity of results was very good. Joints A and B had ultimate strengths of 149,000 and 136,000 pounds per square inch, respectively. Joints C and D exhibited the same strength of 195,000 pounds per square inch.

One unusual feature was noted. Joint D failed at the seam weld rather than the first row of spots. The first row of spots sheared without deformation to the skin or splice plate (Figure 7). The reason for this is not known.

FATIGUE TEST OF WELDED JOINTS

The results of the fatigue testing are shown in Figures 2, 8 and 9.

Joints A and B showed no cracking at less than 1000 and 1300 cycles respectively. Cracking of joints C and D occurred at not less than 2000 and 3000 cycles respectively. The 321 CRES joints have performed better than the AM-355 joints when the number of cycles to first leak are considered. The load parameter for the fatigue testing was pounds per inch of width of the specimen. Thus minor variations in skin thickness (about 0.0005 inch) resulted in slightly different stress levels to which the fatigue specimens were cycled. The maximum stress levels have been calculated and tabulated below:

Joint Designation	Maximum Stress Pound/Square Inch
A	61,400
B	62,400
C	53,600
D	54,600

This variation does not appear to have influenced the test results.

Two specimens of joint C were not cycled to failure because no further useful information would be obtained (Figure 2).

Evidence of atmospheric corrosion was noted on the AM-355 splice plates after one month's exposure to the atmosphere.

ULTIMATE STATIC STRENGTH OF WELDED JOINTS

JOINT	SPLICE PLATE	SKIN MATERIAL	ULTIMATE STRENGTH POUNDS/SQUARE INCH
A	AM 355	301 HALF HARD STAINLESS STEEL	149,000 148,000 149,000 150,000 151,000 AVERAGE 149,000
B	321 CRES	301 HALF HARD STAINLESS STEEL	135,000 135,000 136,000 134,000 138,000 AVERAGE 136,000
C	AM 355	301 EXTRA FULL HARD STAINLESS STEEL	196,000 196,000 199,000 (1) 192,000 194,000 AVERAGE 195,000
D (2)	321 CRES	301 EXTRA FULL HARD STAINLESS STEEL	196,000 199,000 197,000 194,000 190,000 AVERAGE 195,000

(1) LOAD RATE WAS 10 TIMES NORMAL, THEREFORE VALUE NOT INCLUDED IN AVERAGE.
(2) THIS GROUP OF SPECIMENS FAILED AT THE HELIARC SEAM WELD, INSTEAD OF THE FIRST ROW OF SPOT WELDS.

FIGURE 1

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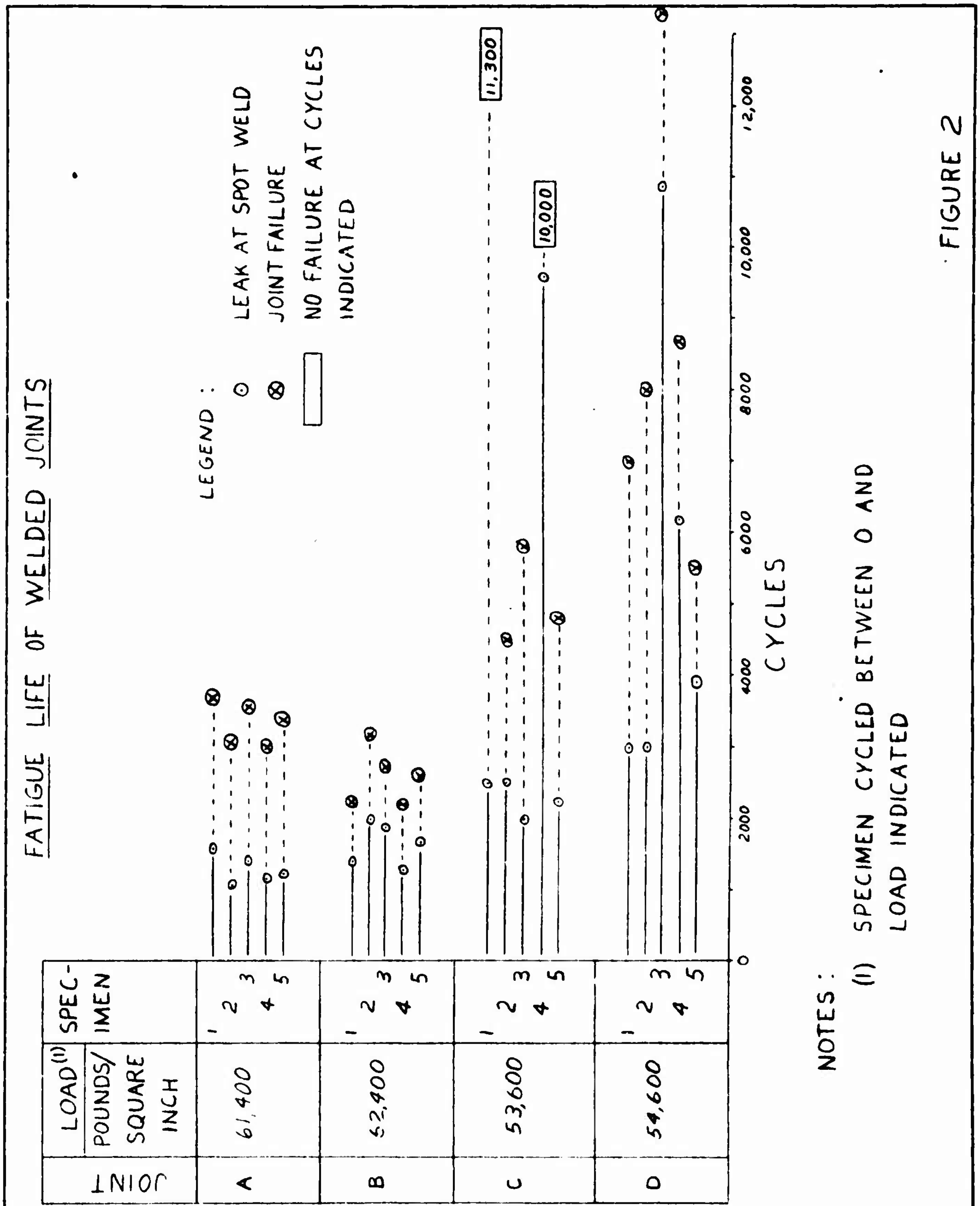

FIGURE 2

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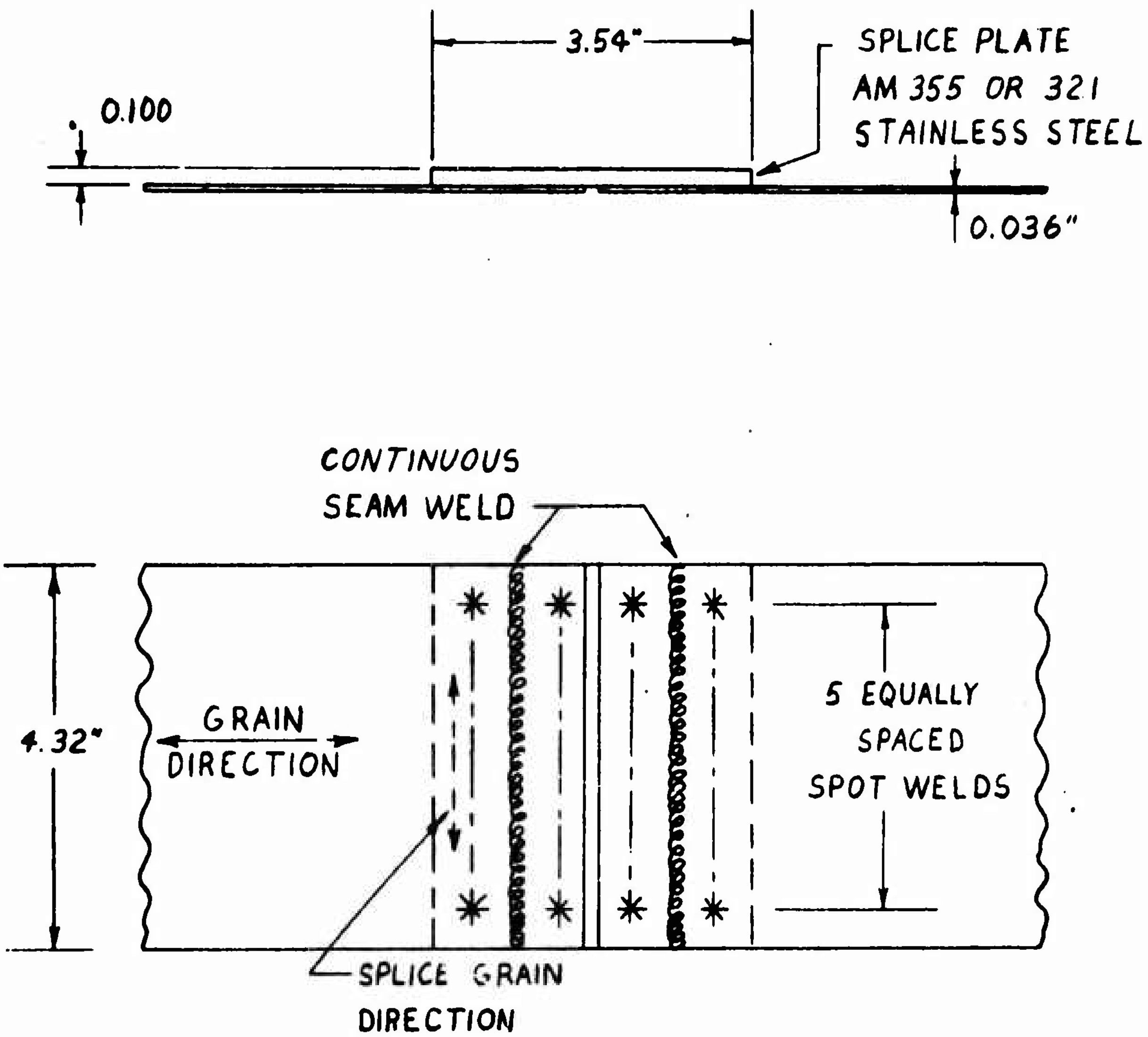
JOINT DRAWING (A & B)

FLAT SPLICE PLATE



NOTE:

(1) SKIN MATERIAL - 0.036" 301 HALF HARD STAINLESS STEEL.

(2) REFERENCE DRAWING 7-07063

FIGURE 3

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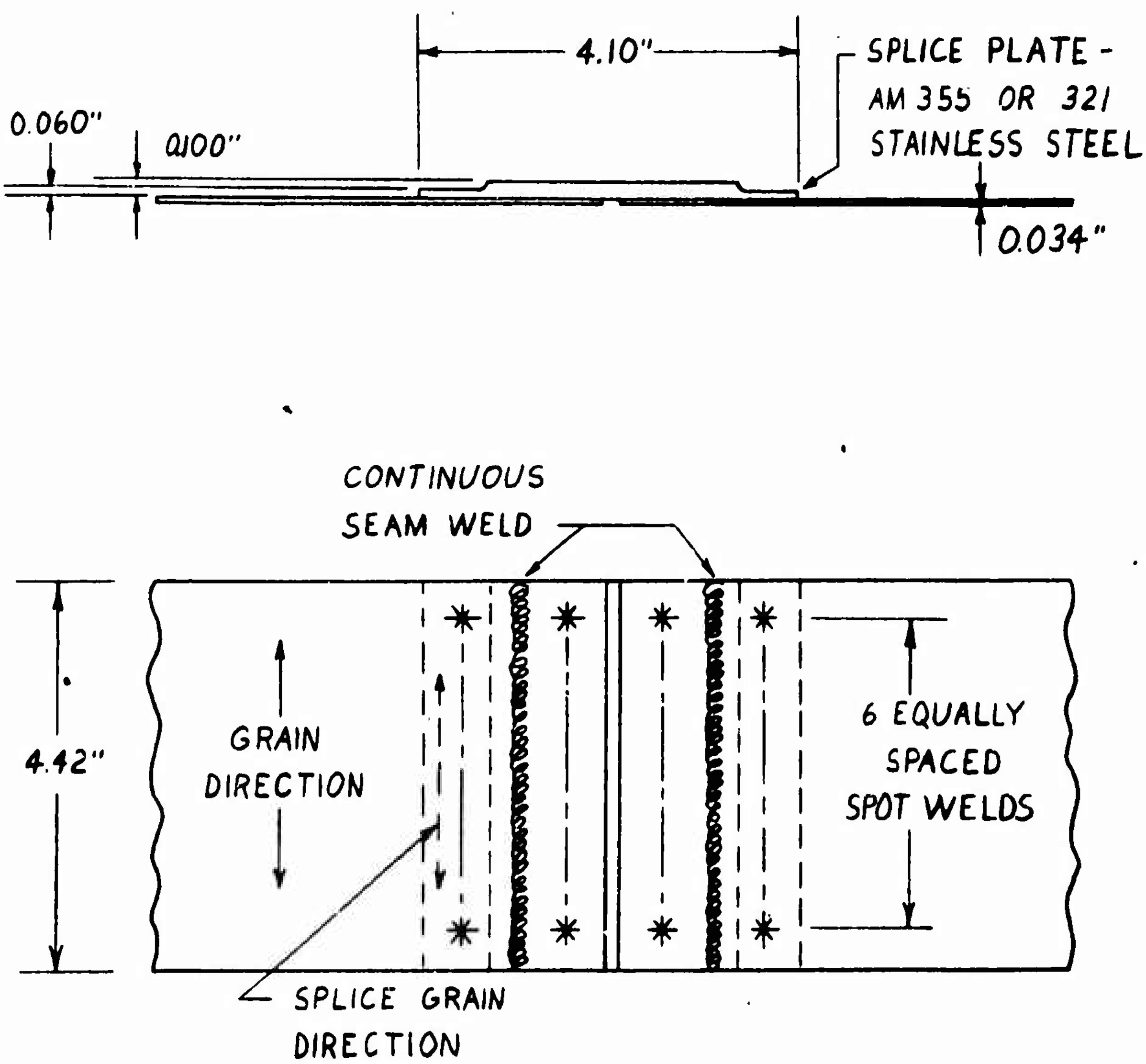
JOINT DRAWING (C & D)

END MILL SPLICE PLATE



NOTE:

(1) SKIN MATERIAL - 0.034" 301 EXTRA FULL HARD STAINLESS STEEL

(2) REFERENCE DRAWING 7-07063

FIGURE 4

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STATIC STRENGTH OF JOINT MATERIALS

MATERIAL	GRAIN DIRECTION (1)	YIELD STRENGTH POUNDS/SQUARE INCH			ULTIMATE STRENGTH POUNDS/SQUARE INCH			% ELONGATION IN 2 INCHES			REMARKS
		MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE	
AM 355	L	60,600	91,000	76,600	179,000	198,000	190,000	3	10	7	DESIRED YIELD WAS 110,000 POUNDS /SQUARE INCH (2)
	T	65,200	92,200	79,700	176,000	197,000	189,000	3	10	7	
321 CRES	L	38,200	41,100	39,400	87,200	88,800	88,100	48	51	50	SATISFACTORY
	T	34,400	36,400	35,400	85,800	87,900	86,700	49	54	51	
301 Ex.F.H. STAINLESS STEEL	L	186,000	198,000	193,100	205,000	211,000	208,000	5	7	6	SATISFACTORY
	T	180,000	193,000	187,000	220,000	226,000	223,000	7	8	8	
301 ½H. STAINLESS STEEL	L	115,000	121,000	117,000	140,000	149,000	143,000	25	28	25	DESIRED ULTIMATE WAS 150,000 POUNDS /SQUARE INCH
	T	111,000	122,000	115,000	144,000	155,000	149,000	20	21	20	

NOTES:
(1) L - LONGITUDINAL, T - TRANSVERSE
(2) DESIRED MINIMUM ELONGATION WAS 8%.

FIGURE 5

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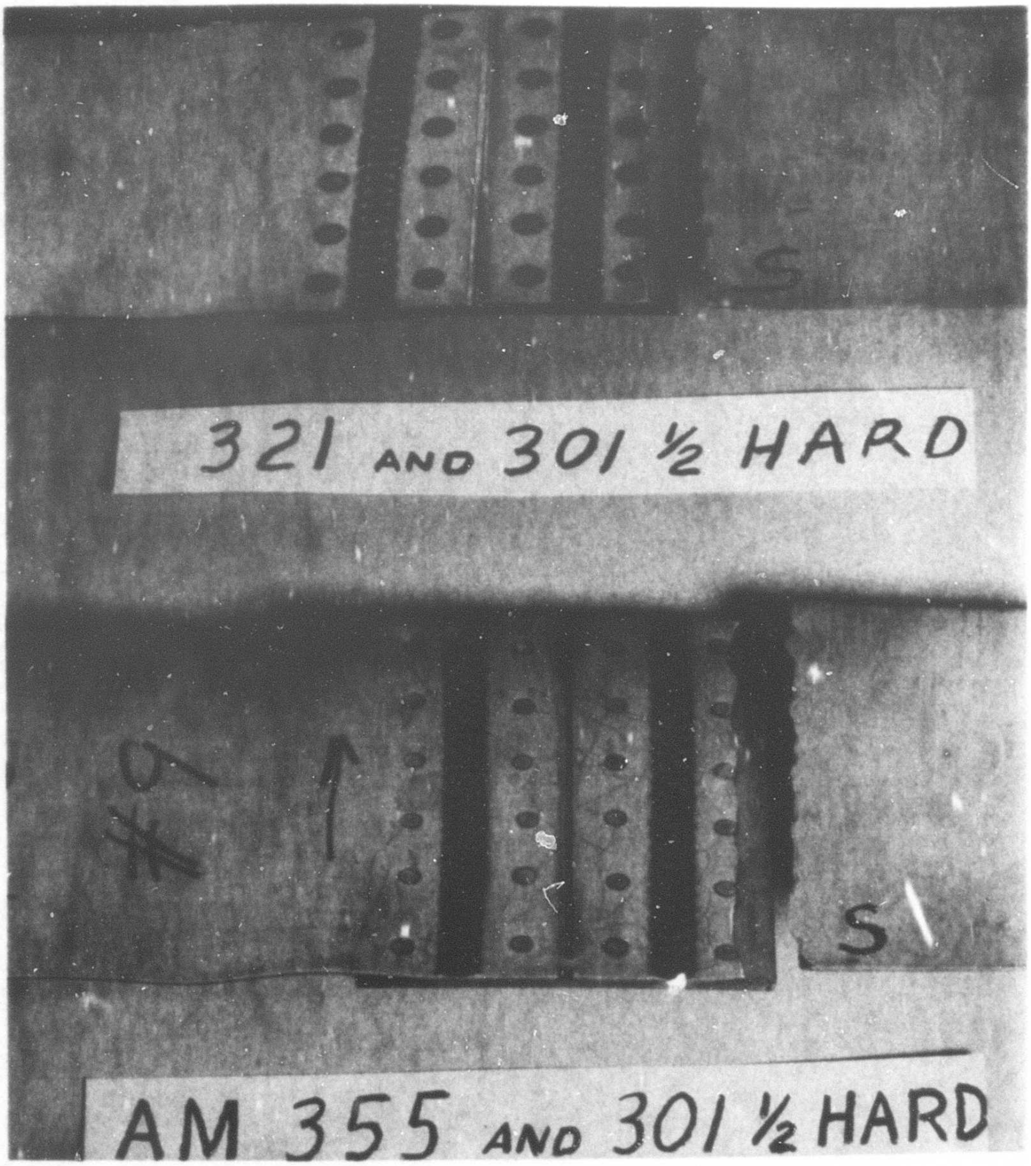

FIGURE 6

STATIC FAILURE OF JOINTS A & B

SPLICE PLATE	SKIN MATERIAL
A AM-355	TYPE 301 (1/2 H) STAINLESS STEEL
B TYPE 321 CRES	TYPE 301 (1/2 H) STAINLESS STEEL

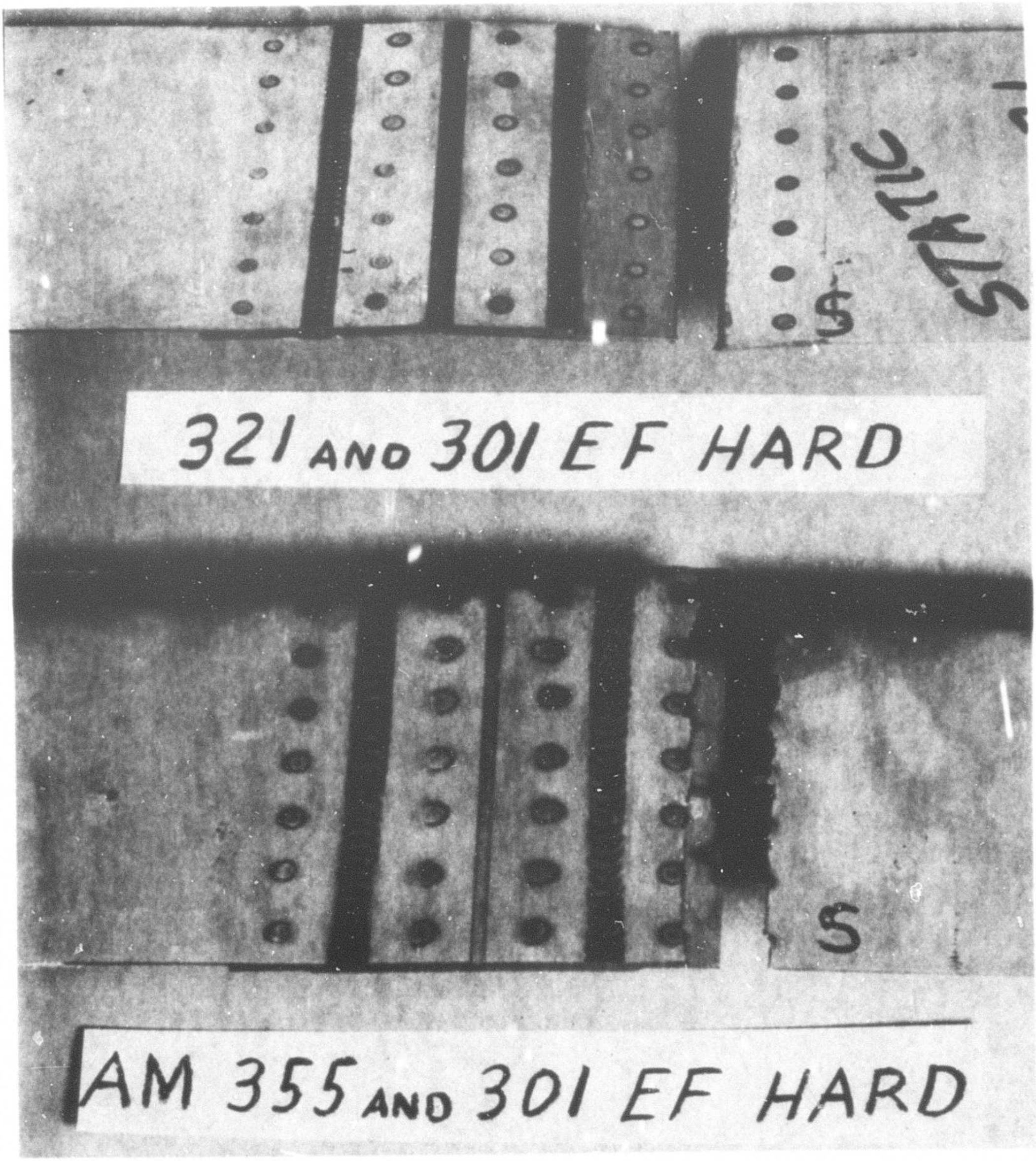

FIGURE 7

STATIC FAILURE OF JOINTS C & D

SPLICE PLATE	SKIN MATERIAL
C AM-355	TYPE 301 (EFH) STAINLESS STEEL
D TYPE 321 CRES	TYPE 301 (EFH) STAINLESS STEEL

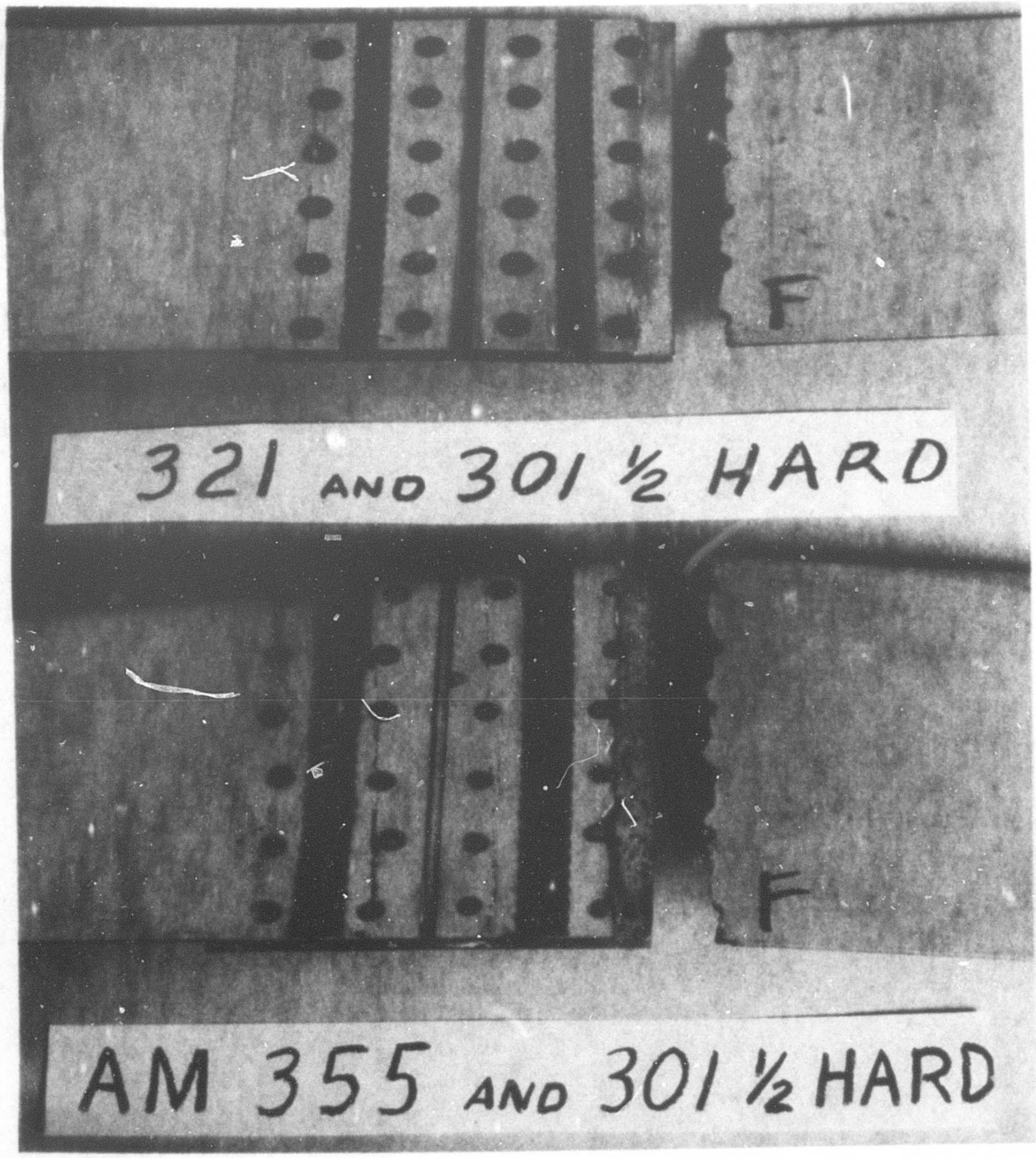

FIGURE 8

FATIGUE FAILURE OF JOINTS A & B

SPLICE PLATE	SKIN MATERIAL
A AM-355	TYPE 301 (1/2 H) STAINLESS STEEL
B TYPE 321 CRES	TYPE 301 (1/2 H) STAINLESS STEEL

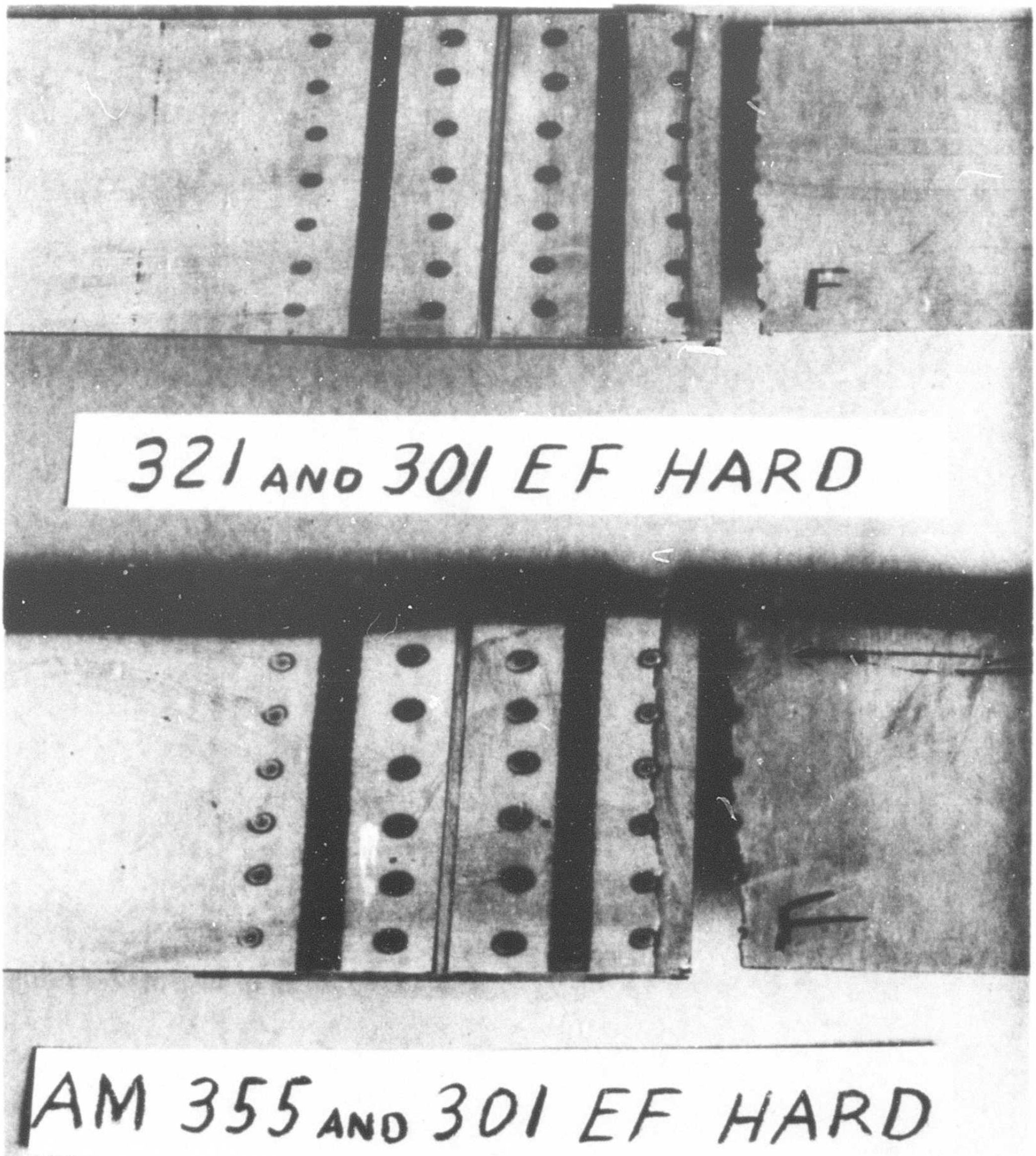

FIGURE 9

FATIGUE FAILURE OF JOINTS C & D

SPLICE PLATE	SKIN MATERIAL
C AM-355	TYPE 301 (EFH) STAINLESS STEEL
D TYPE 321 CRES	TYPE 301 (EFH) STAINLESS STEEL